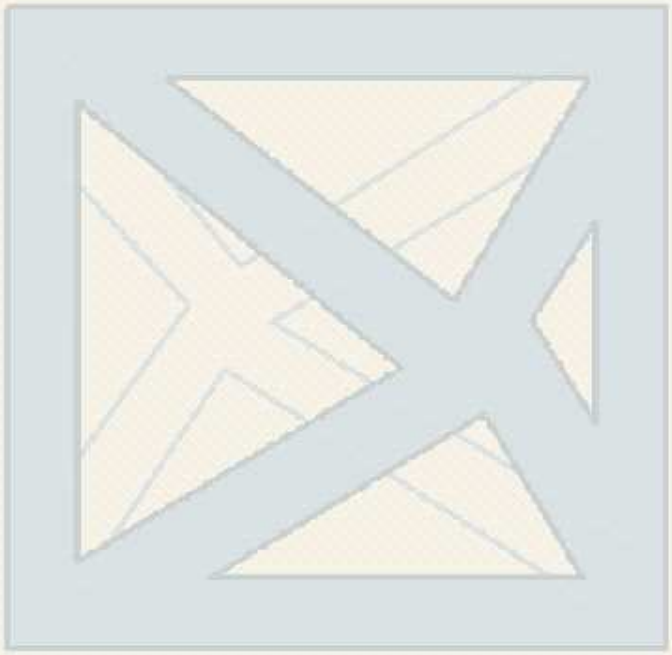
Indicatori complessi

Università degli Studi di Firenze
Dipartimento di Studi Sociali

Indicatori complessi



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Introduction

Measuring processes by:

- *a* ***fundamental*** *process* $\Rightarrow$ lenght, volume
- *a* ***deriving*** *process* $\Rightarrow$ density, velocity
- *a* ***defining*** *process* $\Rightarrow$ socio-economic status

Introduction

In social sciences,
the measurement process requires a design
allowing indicators to be defined:

1. Defining the conceptual framework	⇨	Comprehensive approach
2. Developing the indicators	⇨	Logical modeling (hierarchical design)
3. Managing the complexity	⇨	Analytical process (multi-stages and multi-techniques)
4. Framing the complexity	⇨	Developing a system of indicators

Introduction

Defining the conceptual framework

Developing the indicators

Managing the complexity

Framing the complexity

1.

Defining the conceptual framework

Developing the indicators

Managing the complexity

Framing the complexity

Defining the conceptual framework

Measuring social phenomena

⇩

different conceptual frameworks

⇩

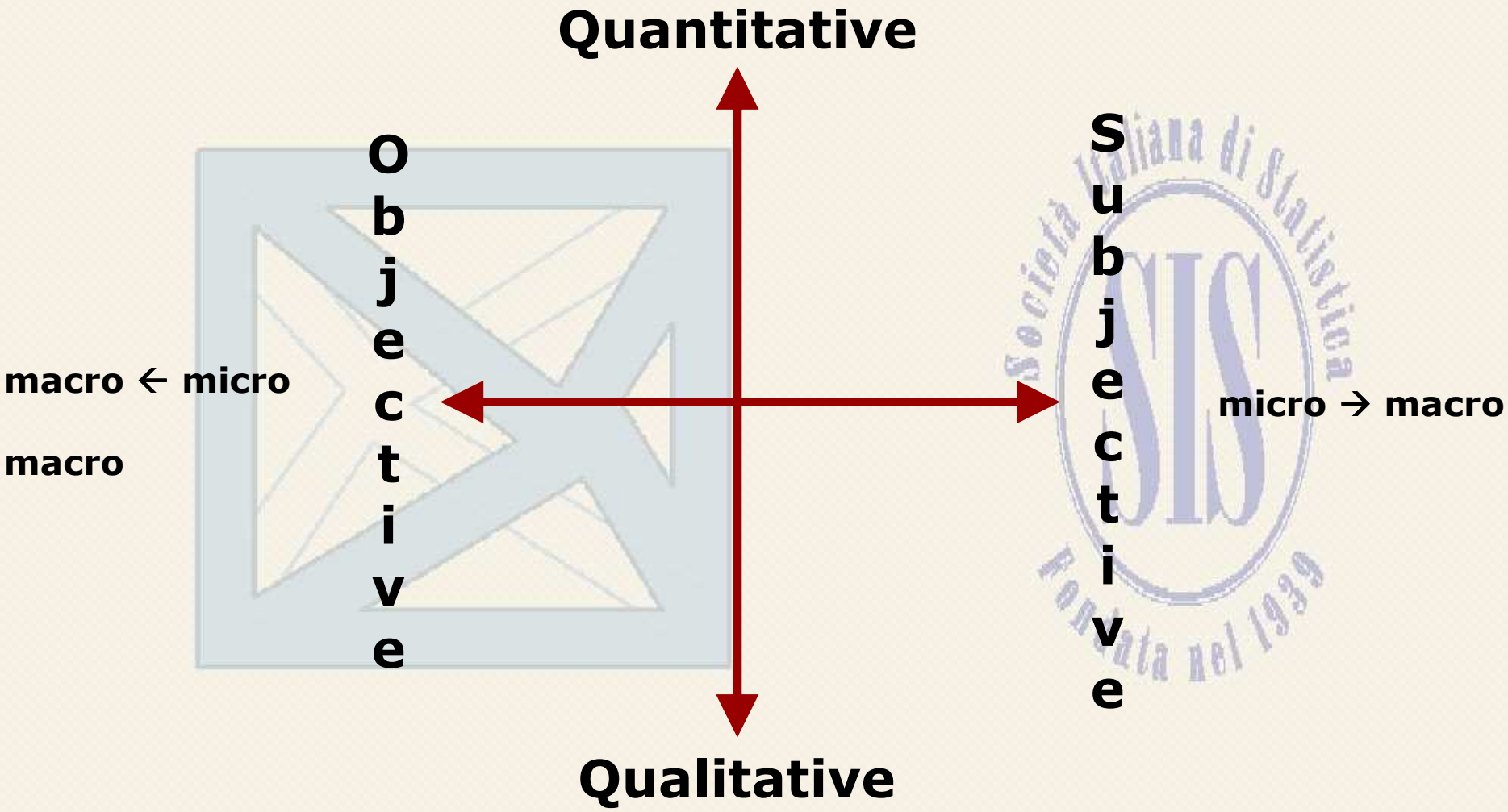
comprehensive

⇩

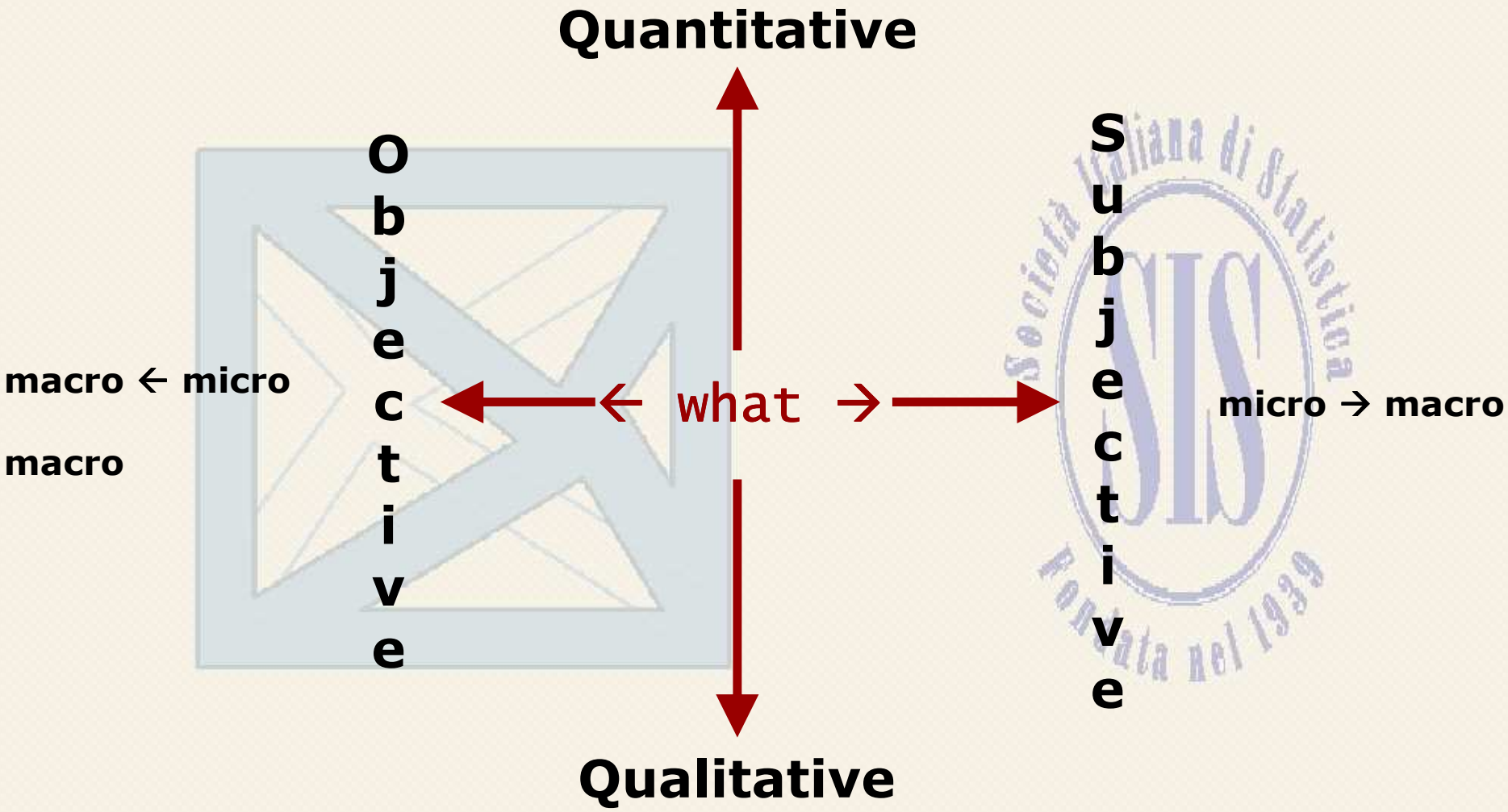
Integration between

objective and **subjective** information

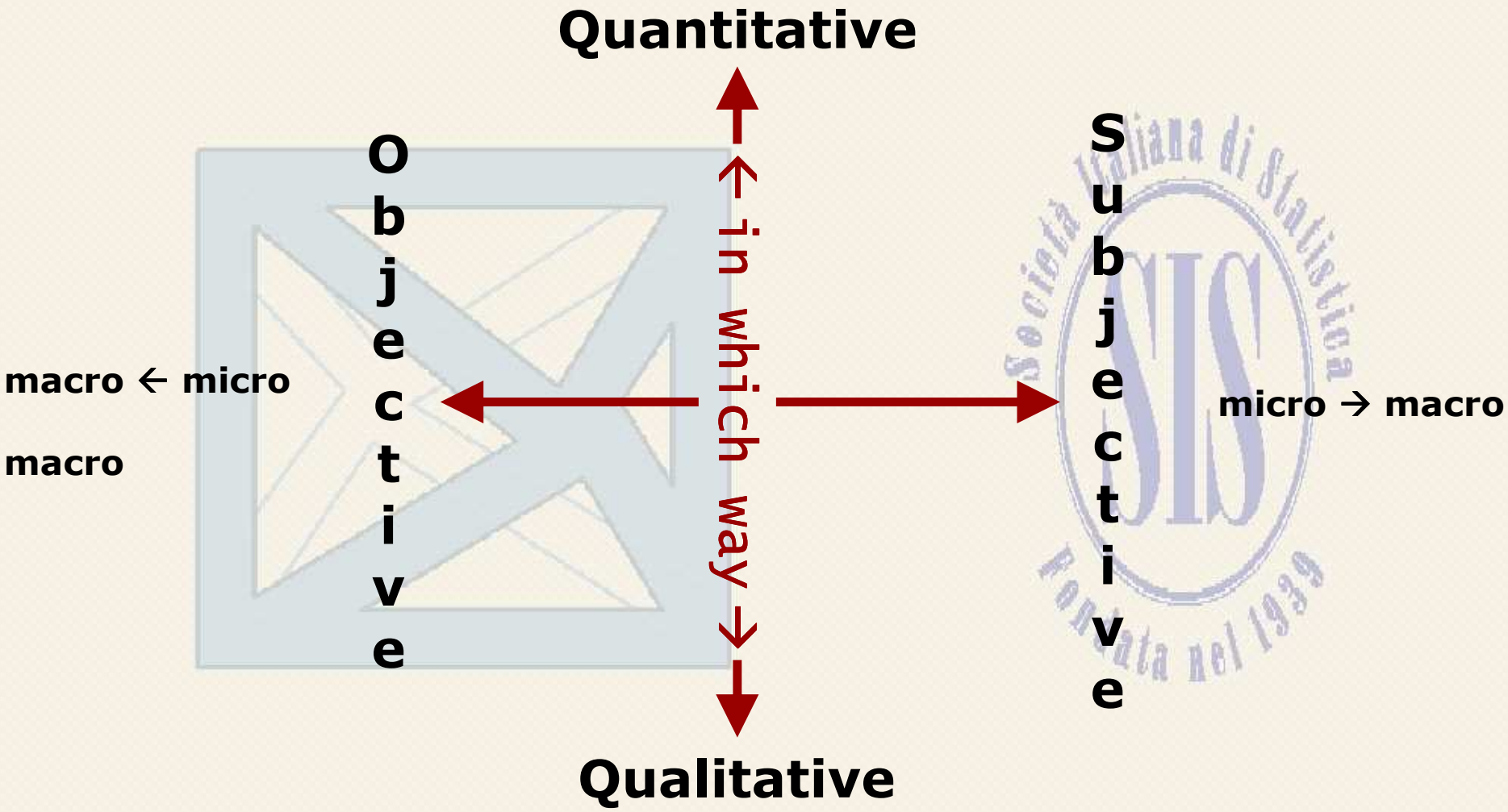
Defining the conceptual framework



Defining the conceptual framework



Defining the conceptual framework



2.

Defining the conceptual framework

Developing the indicators

Managing the complexity

Framing the complexity

Developing the indicators

HIERARCHICAL DESIGN

CONCEPTUAL MODEL

↓

AREAS TO BE INVESTIGATED

↓

LATENT VARIABLES

↓

ELEMENTARY INDICATORS

Developing the indicators

Conceptual model ↴

defines

the phenomenon to be studied,

the domains and the general aspects

characterizing the phenomenon

⇩

process of abstraction

Developing the indicators

Areas to be investigated

⇩

different aspects
allowing the phenomenon
to be specified consistently
with the conceptual model

Developing the indicators

Latent variables ↴

elements to be observed

in order to define

the corresponding area

Their definition requires:

- theoretical assumptions (dimensionality)
- empirical statements

Developing the indicators

Elementary indicators ↴

what can be actually measured

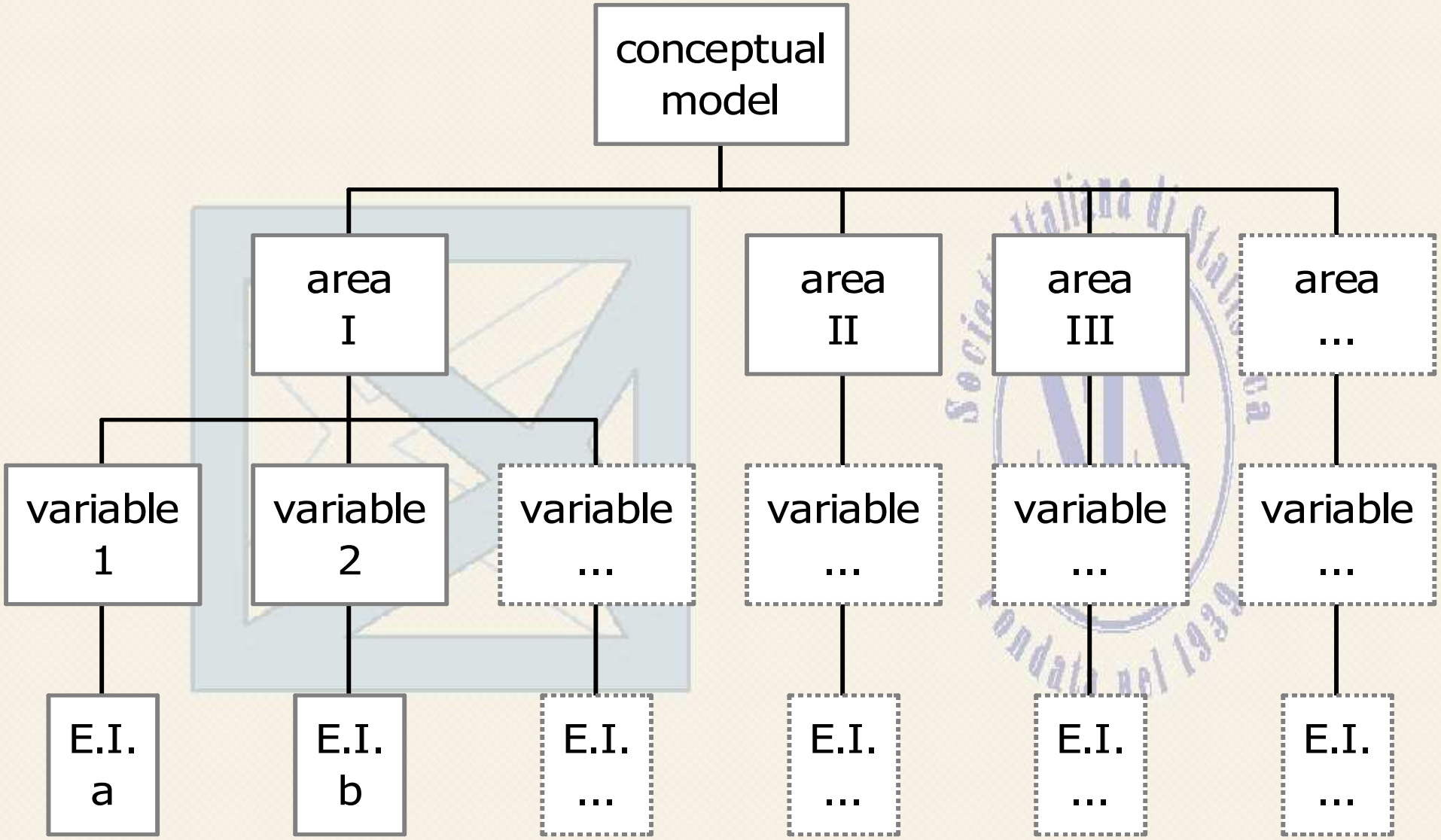
in order to investigate the variable

They are defined by:

- appropriate techniques
- a system allowing observed values

  to be interpreted and evaluated

Developing the indicators



Developing the indicators

COMPONENT	THE QUESTION TO WHICH THE COMPONENT GIVES AN ANSWER	DEFINITION OF THE COMPONENT
CONCEPTUAL MODEL	Phenomena to be studied	The conceptual model defines the **phenomena** to be studied and the domains and the general aspects that characterize the phenomena
AREAS/PILLARS TO BE INVESTIGATED	Aspects defining the phenomenon	Each area represents each **aspect** that characterizes and defines the theoretical model
LATENT VARIABLES	Elements to be observed	Each variable represents each **element** that has to be observed in order to define the corresponding area. The variable is named **latent** since is not observable directly
ELEMENTARY INDICATORS (E.I.)	In which way each element has to be measured	Each indicator (item, in subjective measurement) represents **what is actually measured** for each variable and is defined by appropriate techniques and by a system that allows observed value to be evaluated and interpreted.

Developing the indicators

Definition of relationships between

- latent variables and corresponding indicators ⇒ **model of measurement**
- latent variables
- elementary indicators

Developing the indicators

Two different conceptual approaches:

- models with **reflective** indicators
- models with **formative** indicators

Developing the indicators

Models with reflective indicators

⇩

indicators → ***functions of the latent variable***

⇩

changes in the latent variable are reflected in changes in the observable indicators

top-down explanatory approach

Developing the indicators

Models with formative indicators

⇩

indicators → ***causal in nature***

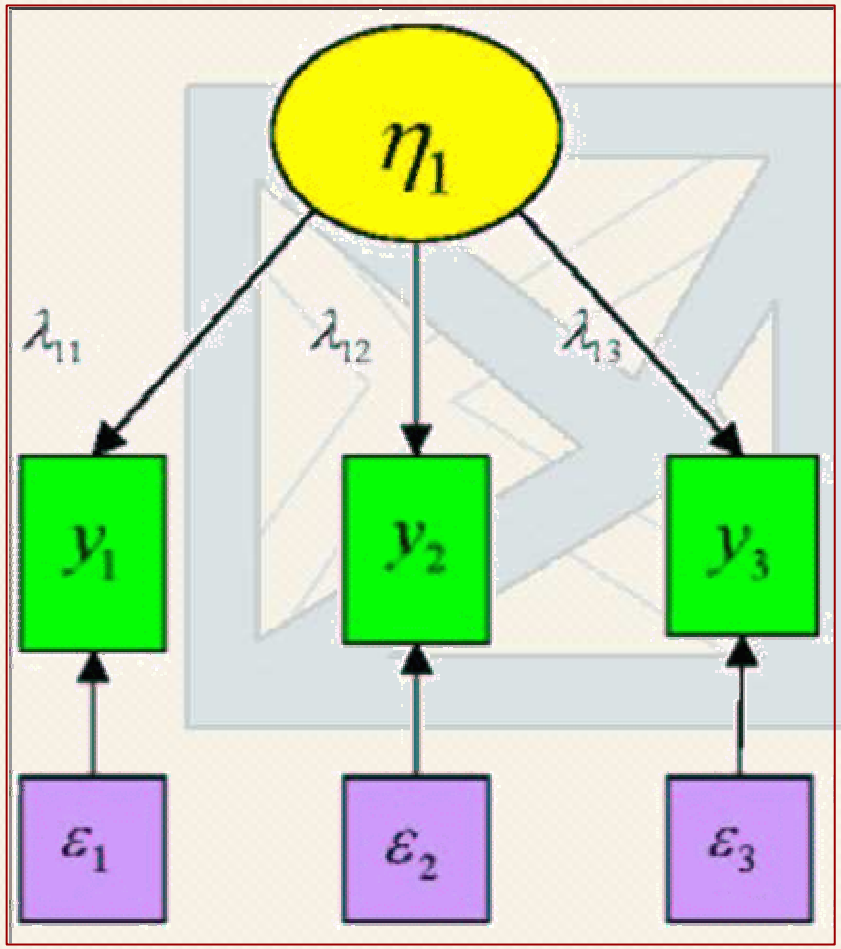
⇩

changes in the indicators determine changes in the definition / value of the latent variable

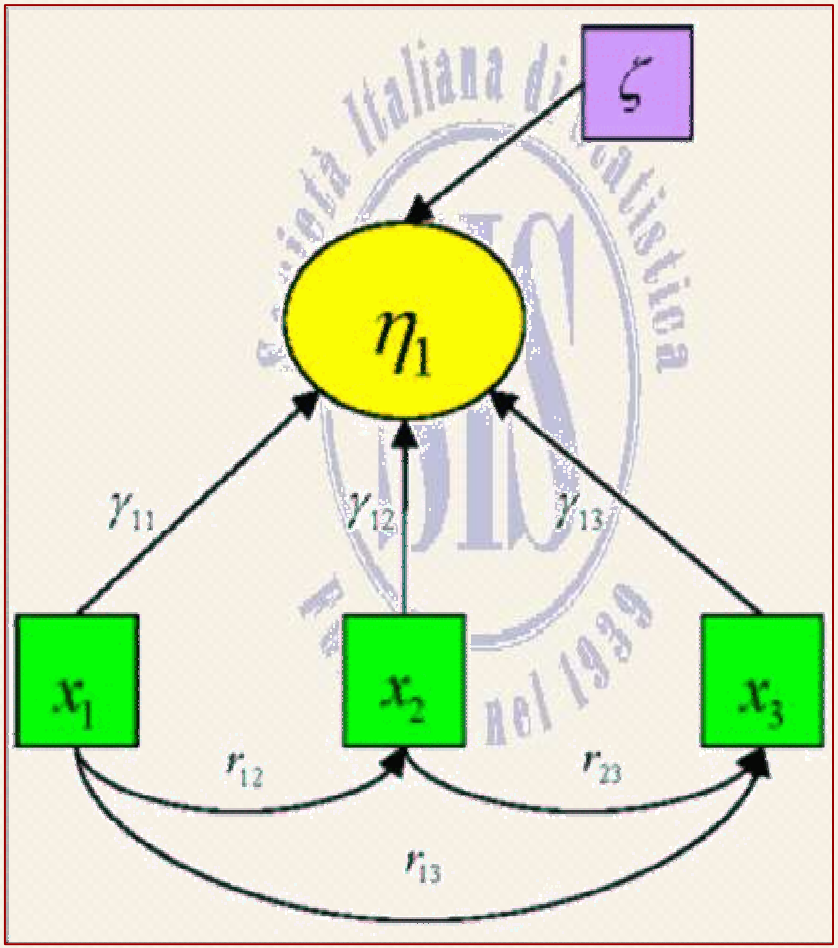
⇧ ***bottom-up*** explanatory approach

Developing the indicators

Reflective



Formative



3.

Defining the conceptual framework

Developing the indicators

Managing the complexity

Framing the complexity

Managing the complexity

Consistent application of the hierarchical design produces a **complex** data structure.

The complexity refers to

three data dimensions

to be managed

Managing the complexity

- ***Elementary Indicators***

  (several indicators for each variables)

- observed ***Cases/Units***

  (several units for each observation)

- ***Variables***

  (several variables are defined)

Managing the complexity

Strategies to manage the complexity

⇩

each data dimension may require a particular treatment:

Managing the complexity

A. aggregation of elementary indicators

B. aggregation of cases/units

C. integration of different variables

Managing the complexity

Stage	Perspectives		Level of analysis	Analytical issues
i	**Aggregating elementary indicators**	Creation of complex indicators by aggregating elementary indicators	From elementary indicators to complex indicators	• Reflective approach → synthetic indicators • Formative approach → composite indicators
⇩				
ii	**Relating variables**	Understanding relationships between characteristics in order to integrate / merge information (e.g. objective and subjective)	Micro level	Different solutions (consistently with conceptual framework)
⇩				
iii	**Aggregating observed units**	Creation of macro-units by aggregating elementary units	From micro units to macro units	Following - homogeneity criterion - functionality criterion
⇩				
iv	**Relating variables**	Understanding relationships between characteristics in order to integrate / merge information (e.g. objective and subjective)	Macro level	Different solutions (consistently with conceptual framework)

Managing the complexity: A

Aggregating elementary indicators:

two different criteria

Managing the complexity: A

- **Reflective** criterion
  - *(homogeneity)*
    - **Synthetic indicator**
- **Formative** criterion
  - *(heterogeneity)*
    - **Composite indicator**

Managing the complexity: A

Reflective approach

Properties of reflective indicators (Diamantopoulos & Winklhofer, 2001):

- indicator are interchangeable (the removal of an indicator does not change the essential nature of the underlying construct),
- correlations between indicators are explained by the measurement model,
- two uncorrelated indicators cannot measure the same construct (internal consistency),
- each indicator has error term,
- the measurement model can be estimated in the ambit of a larger model that incorporates effects of the latent variable.

Managing the complexity: A

- **Reflective approach**

assessment of reliability and validity

⇩

statistical approach

⇩

consistent with → **factor models**

Managing the complexity: A

Reflective approach

ASSUMPTION

Total variance of each indicator = sum of **three** uncorrelated components:

- ***common variance***
  - explained by → latent variable
  - measured by → correlation between indicators
- **specific variance**
  - not correlated with the other indicators
- **error**, portion of the total variance
  - not correlated with the previous

Managing the complexity: A

Reflective approach

ASSUMPTION

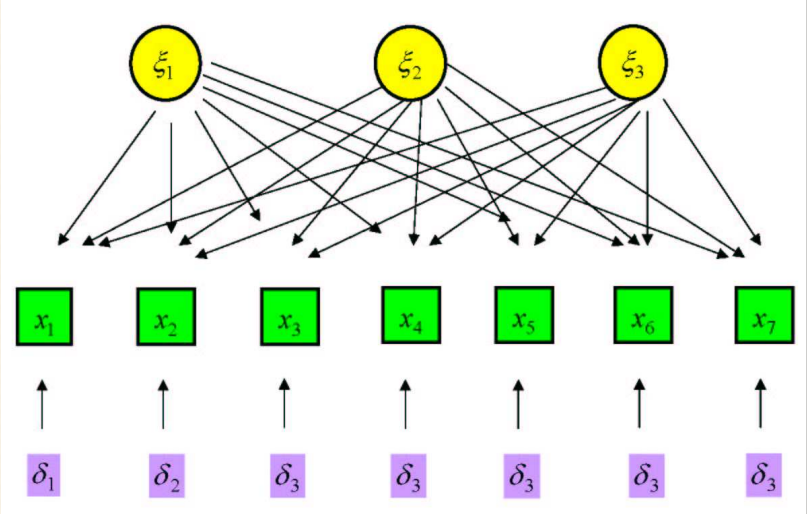
total variance	=	common variance	+	specific variance	+	error
$\sigma^2_{x_i}$	=	$\sigma^2_{x_{ic}}$	+	$\sigma^2_{x_{is}}$	+	$\sigma^2_{x_{ie}}$
total variance	=	communality	+	unique variance (uniqueness)		
$\sigma^2_{x_i}$	=	$h^2_{x_i}$	+	$\delta^2_{x_i}$		
total variance		reliable variance			+	error
$\sigma^2_{x_i}$	=	$h^2_{x_i} + \sigma^2_{x_{is}}$			+	$1-\left(h^2_{x_i} + \sigma^2_{x_{is}}\right)$
$\sigma^2_{x_i}$	=	$\lambda^2_{x_i\xi_1}$ + $\lambda^2_{x_i\xi_2}$ + ... + $\lambda^2_{x_i\xi_m}$	+	$\left(1-h^2_{x_i}\right)$		
fundamental equation of common factor model						
$\sigma^2_{x_i} = \sum_{j=1}^{m} \lambda^2_{x_i\xi_j} + \delta^2_{x_i}$						

Managing the complexity: A

Reflective approach

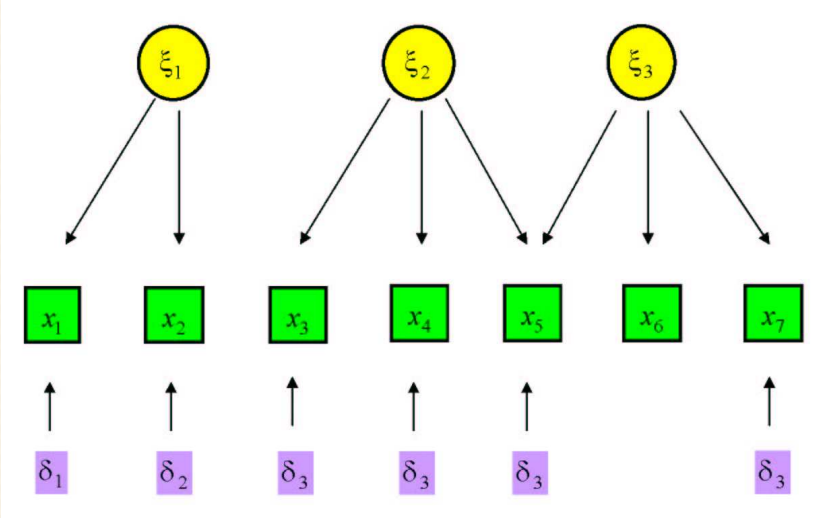
ASSUMPTION

explorative approach



- all the indicators are influenced by all the latent variables;
- each indicator is influenced by a unique factor;
- unique factors are not interrelated.

confirmatory approach



- each indicator (but one) is influenced by one latent variable;
- indicators are not all influenced by a unique factor;
- unique factors are not interrelated.

Managing the complexity: A

Reflective approach

PARTICULAR APPROACHES:

				Scaling models' characteristics				
				Dimensionality	**Nature of data**	**Scaling technique**	**Criterion for testing the model**	**Standard of measurement: final (synthetic) score assigned to**
Scaling models	***Additive***	*Uni-dimensional*		Uni	Single-stimulus	Not-comparative	Internal consistency	Cases
		Multidimensional		Multi	Single-stimulus	Not-comparative	*Dimensionality of the items*	Cases
	Cumulative	Thurstone model (differential scale)		Uni	Stimulus comparison	Comparative (pair comparison or rank-order)	Metrics between items	Items
		Q methodology		Uni	Stimulus comparison	Comparative (rank-order or comparative rating)		Items
		Deterministic	Guttman	Uni	Single-stimulus	Not-comparative	Scalogram analysis: reproducibility, scalability and ability to predict	Cases and items
			Multidimensional Scalogram Analysis (MSA)	Bi			Regionality and contiguity	Cases and items
			Partial Ordered Scalogram Analysis (POSA)	Bi			Correct representation	Cases and items
		Probabilistic	Monotone (one or more parameters)		Single-stimulus	Not-comparative	• parameters estimation (maximum likelihood) • goodness of fit (misfit and residuals analysis)	Cases and items (without condensation)
	Perceptual Mapping	Multidimensional scaling		Multi	Similarities	Comparative (pair comparison)	Goodness of fit of distances to proximities (stress, alienation)	Items
		Unfolding		Uni & Multi	Preferential choice	Comparative	Goodness of fit of distances to ordinal preferences	Cases and items
	Conjoint model			Multi	Preferential choice	Comparative (rank-order)	Goodness of fit of the model (part-worth) to the ranking	Items at individual level

Managing the complexity: A

Formative approach

Properties of formative indicators (Diamantopoulos & Winklhofer, 2001):

- indicator are not interchangeable (omitting an indicator is omitting part of the construct),
- correlations between indicators are not explained by the measurement model,
- two uncorrelated indicators can both serve as meaningful indicators of the same construct (internal consistency in not important),
- indicators do not have error terms

Managing the complexity: A

- **Formative approach**

ASSUMPTION

The latent variable = linear sum of indicators:

assessment of reliability and validity

⇩

statistical approach

⇩

consistent with → **principal components specification**

Managing the complexity: A

Formative approach

PARTICULAR APPROACH: COMPOSITE INDICATORS

The methodology requires techniques aimed at

1. verifying the **dimensionality** of elementary indicators (***dimensional analysis***)
2. defining the **importance** of elementary indicators (***weighting criteria***)
3. identifying the **aggregating technique** (***aggregating-over-indicators techniques***)
4. assessing the **robustness** of the synthetic indicator → correct and stable measures (***uncertainty analysis, sensitivity analysis***)
5. assessing the **discriminant capacity** of the synthetic indicator (*ascertainment of selectivity* and *identification of* ***cut-point*** *or* ***cut-off*** *values*)

Managing the complexity: B

Aggregating observed units:

from micro to macro units

Managing the complexity: B

Aggregation of cases/units is required in order to lead information to be analysed at the same level

		LEVEL of observation	
		Micro	Macro
INFORMATION	objective	individual living conditions	population or territory information
	subjective	subjective well-being	*not observable*

Managing the complexity: B

Objective information

a. **Compositional**

e.g. proportion of people living in poverty

b. **Contextual**

not observable at individual level

Managing the complexity: B

Subjective information

a. Aggregation through **homogeneity** criterion (typologies) ⇒ analytical approaches

b. Aggregation through **functionality** criterion (areas, …) ⇒ analytical approaches?

Managing the complexity: B

a. ***Homogeneity criterion***

the values are aggregated if the individual cases are homogeneous according to the characteristics of interest

Managing the complexity: B

*b. **Functionality criterion***

the values are aggregated if the individuals belong to pre-existent higher-level units defined in terms of:

- ***groups** (social, generational, etc.)*
- ***areas** (geographical, administrative, etc.)*
- ***time periods** (years, decades, etc.)*

Managing the complexity: C

Relating variables:

(at micro and macro level)

Managing the complexity: C

i. Structural models approach
ii. Multi-level approach
iii. Life-course perspective
iv. Composite indicators

Managing the complexity: C

i. Structural models approach

OBJECTIVE → testing and estimating causal relationships using a combination of statistical data and qualitative causal assumptions

PROS → estimation of reliability of measurement and, consequently, structural relations between latent variables

CONS → strong acceptance of the direction of the relation between objective and subjective indicators is required

Managing the complexity: C

ii. Multi-level approach

OBJECTIVE → simultaneous analysis of outcomes in relation to determinants measured at different levels

PROS → description of relationships between subjective well-being ("outcome" variable), individual objective characteristics (micro-level living conditions), and territorial characteristics (macro-level living conditions)

CONS → strong assumption is required: people living in the same territory share the same macro-level living conditions that contributes - together with the micro-level living conditions - to subjective well-being

Managing the complexity: C

iii. Life-course perspective

OBJECTIVE → status at any given individual state (age, sex, marital status) not only reflecting contemporary conditions but also embodying prior living circumstances

PROS → possibility to study people's developmental trajectories (environmental and social) over time, by considering also the historical period in which they live, in reference to their society's social, economic, political, and ecological context

CONS → difficulty to obtain detailed and consistent individual longitudinal data and by the complexity of managing, analysing, and modelling this kind of data

Managing the complexity: C

iV. Composite indicators

OBJECTIVE → aggregation of objective and subjective indicators in a unique value referring to each unit of interest

PROS → manageability of the obtained results

CONS → conceptual, interpretative and analytical problems of the obtained aggregation

4.

Defining the conceptual framework

Developing the indicators

Managing the complexity

Framing the complexity

Framing the complexity

A frame is needed allowing the conceptual framework to be put in a concrete form

↓

“system of indicators”

Framing the complexity

Characteristics of information in systems of indicators:

- **Objectivity** → equal, comparable results
- **Quantification** → quantitative values
- **Efficiency and fidelity** → communication of results
- **Economicity** → simple, standardized, up-to-datable information
- **Generalization** → exportability of the system
- **Joint development** → shared by all the actors

Framing the complexity

Basic requirements defining a system of indicators:

Key Elements	•Conceptual Framework requested in order to identify and justify the selection of dimension to be measured •System Architecture requested in order to support the basic structure and to define the measurement procedures •Definition and selection of the dimension to be measured •Identificaion of units to be monitored •Organization of measuring and monitoring procedures
Formal criteria to be respected	•Comprehensiveness •Consistency •Non redundancy •parsimoniousness

Framing the complexity

A Functions of systems of indicators

B Elements defining a system of indicators

C Characteristics of indicators within a system

Framing the complexity: A

A.

Functions of systems of indicators

Framing the complexity: A

Functions can be seen in cumulative terms (each requires the previous) :

- Monitoring
- Reporting
- Forecasting
- Program/performance evaluation
- Accounting
- Assessment

Framing the complexity: A

- **Monitoring** → capacity of the system to monitor changes over time and meet the need of improving knowledge
- Reporting
- Forecasting
- Program/performance evaluation
- Accounting
- Assessment

Framing the complexity: A

- Monitoring
- **Reporting** → *monitoring* **+** *analysis* **+** *interpretation*
- Forecasting
- Program/performance evaluation
- Accounting
- Assessment

Framing the complexity: A

- Monitoring
- Reporting
- **Forecasting** → trends in observed reality
- Program/performance evaluation
- Accounting
- Assessment

Framing the complexity: A

- Monitoring
- Reporting
- Forecasting
- **Program/performance evaluation** → problem definition, policy choice and evaluation of alternatives and program monitoring
- Accounting
- Assessment

Framing the complexity: A

- Monitoring
- Reporting
- Forecasting
- Program/performance evaluation
- **Accounting** → supporting decision concerning the allocation and the destination of resources
- Assessment

Framing the complexity: A

- Monitoring
- Reporting
- Forecasting
- Program/performance evaluation
- Accounting
- **Assessment** → to certificate or judge subjects (individuals or institutions) by discriminating their performances or to infer functioning of institutions, enterprises or systems.

Framing the complexity: B

B.

Elements defining a system of indicators

Framing the complexity: B

Main elements

i. Aims
ii. Structure
iii. Analytical approaches
iv. Interpretative and evaluating models

Framing the complexity: B

i. Aims

Conceptual	→	goals
Operative	→	objectives
Planning	→	actions

⇩

indicators		function
- input	→	measuring resources available in the system and indicating some sort of inputs into a process
- process (intermediate output)	→	monitoring the basic progress of implementing the actions defined and outlined at strategic level
- output/outcome	→	monitoring direct results of actions
- impact	→	monitoring progress and improvement towards goals and objectives achievement

Framing the complexity: B

ii. Structure

- **Vertical** → from local to higher level
- **Horizontal** → different ambits at the same level
- **Local** → monitoring internal organization of the level and referring to external parameters

Framing the complexity: B

iii. Analytical approaches

- Trend analysis
- Monitoring analysis
- Reporting analysis
- Benchmarking analysis
- Impact assessment
- Evaluation analysis

Framing the complexity: B

iv. Interpretative and evaluating models

The observed results can be interpreted only according to a specific reference frame.

This can also define and identify particular *standard-values*, which can be defined *a priori*, according to the objectives or empirical observations (e.g. surveys).

Framing the complexity: C

C.

Characteristics of indicators within a system

Framing the complexity: C

Classification

- *Purposes*
- *Governance contexts*
- *Perspectives of observation*
- *Forms of observation*
- *Levels of communication*

Framing the complexity: C

Classification

- *Purposes*

⇨ descriptive (describing a reality)
⇨ explicative (interpreting a reality)
⇨ predictive (identifying trends)
⇨ normative (supporting decisions)
⇨ problem oriented (testing hypotheses)
⇨ evaluating practical – directionable – actionable (process – advancement – effect)

Framing the complexity: C

Classification

- *Governance context*

⇨ Public debates
⇨ Policy guidance
⇨ Administrative guidance

Framing the complexity: C

Classification

- *Perspective of observation*

⇨ Conglomerative approach measures ⇒ capturing advances made by the society as a whole

⇨ Deprivational approach ⇒ assessing status of the deprived

We need both, for an adequate understanding of the process

Framing the complexity: C

Classification

- *Forms of observation*

⇨ Status indicators ⇒ capturing a reality in a particular moment

⇨ Trend indicators ⇒ observing a reality along time (longitudinal design of observation)

Framing the complexity: C

Classification

- *Level of communication*

⇨ Cold indicators ⇒ complex and difficult, for specialists

⇨ Hot indicators ⇒ simple and easy

⇨ Warm indicators ⇒ good balance between quality, comprehensibility and resonance

Framing the complexity: C

Quality

I. *Methodological soundness*
II. *Integrity*
III. *Serviceability*
IV. *Accessibility*

Framing the complexity: C

An indicator should be able to:	• Define and describe • Observe unequivocally and stably • Record by a degree of distortion as low as possibile	**(I) METHODOLOGICAL SOUNDNESS**
	• Adhere to the principle of objectivity	**(II) INTEGRITY**
	• Reflect adequately the conceptual model • Meet current ad potential users' needs • Be observed through realistic efforts and costs • Reflect the leght of time between its availability and the event of phenomenon it describes • Be analyzed in order to record differences and disparities	**(III) SERVICEABILITY**
	•Be spread	**(IV) ACCESSIBILITY**

Framing the complexity: C

Prerequisity of quality

- *Legal and institutional environment (coordination within and across institutions)*
- *Resources available for statistics work*
- *Quality awareness informing statistical work*

Framing the complexity: C

Problems in selecting indicators

Different issues need to be addressed

in order to

selecting and managing indicators,

especially when this is carried out into

a complex system

allowing the accomplishment of functions like

monitoring, reporting and accounting

Framing the complexity: C

Problems in selecting indicators

Michalos (2006) identified **15** different issues related to the combination of social, economic and environmental indicators.

The issues collectively yield over **200,000** possible combinations representing at least that many different kinds of systems:

Framing the complexity: C

Problems in selecting indicators

- Settlement/aggregation area sizes
- Time frames
- Population composition
- Domains of life composition
- Objective versus subjective indicators
- Positive versus negative indicators
- Input versus output indicators
- Benefits and costs
- Measurement scales
- Report writers
- Report readers
- Quality-of-life model
- Distributions
- Distance impacts
- Causal relations

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Thank you for your attention